A Review of Brain Tumor Segmentation of MRI Image Using Machine Learning Algorithm

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Abstract: Brain Tumor is one of the rapid life-threatening diseases challenging millions of people. A Brain Tumor Detection and Classification system is essential to ensure early Detection and Categorization of Tumor. Since Wrong identification leads to Dreadful and Fatal results, the classification and segmentation techniques should provide High Level Accuracy while performing Tumor classification. So, Brain tumor detection, type classification and segmentation are crucial tasks to evaluate the tumors and make a treatment decision accordingly. On the other side influence of machine learning becomes larger and larger in our life's and our society, artificial intelligence might also start playing an important role in medical diagnosis and support of doctors and surgeons. This paper is focused on review of those papers which include segmentation, detection and classification of brain tumors. Many machine learning approaches towards brain tumor detection have already been made. However, these approaches, even though yielding good results, are not used yet. Therefore, this research topic remains important and still requires attention.

***Keywords*:** Brain Tumor, Magnetic resonance imaging, Segmentation, Machine Learning algorithm

I. Introduction

Brain is the one of the most complex organs in the human body that works with billions of cells. A brain tumor arises when there is uncontrolled division of cells forming an abnormal group of cells around or inside the brain. Brain tumors can be classified in many ways, for instance, primary and secondary tumors or metastatic brain tumors. The former represents about 70% of all brain tumors, while secondary tumors are the residuals 30%. This classification is determined according to tumors origin just as tumors first originate in the brain are called primary tumors. On the other side, tumors first arise in any other part of the body and then transferred to the brain are called secondary tumors, and most of them are malignant.

These tumors can be cancerous (malignant) or non-cancerous (benign). Malignant brain tumors grow fast and spread to other areas of the brain and spine and compared to benign tumors, they might be more life-threatening. It may be primary or secondary type. A more detailed categorization have classified these tumors into four grades. Gliomas are considered as the common type of primary brain tumor in adults and according to Gliomas are rated from I to IV as per the World Health Organization's grading system. 'Grade I' tumors have cells that are benign mainly normal in appearance. 'Grade II' tumors appear to be slightly abnormal. 'Grade III' tumors have cells that are malignant and clearly abnormal. The most severe type of brain tumors which contain fast-spreading and abnormal cells are considered as 'Grade IV'. Early detection mainly plays a major role in treatment and recovery of the patient. Diagnosing a brain tumor and its grade usually undergoes a complicated and time-consuming process.

II. Related works

A. Multi – classification of brain tumor images using deep neural network

Brain tumor classification is a difficult task to evaluate the tumors and make treatment decision according to their classes. There are many imaging techniques that won't to detect brain tumors. However, MRI is most commonly used due to its image quality and the fact of relying on no ionizing radiation. Deep learning (DL) is an area of machine learning that has recently demonstrated great promise, primarily in classification and segmentation issues. In this paper, a DL model supported a convolutional neural network is proposed to classify different brain tumor types using two publicly available datasets. The former one classifies those tumors into (meningioma, glioma, and pituitary tumor). The other one differentiates between these three glioma grades. The datasets include 233 and 73 patients with a total of 3064 and 516 images on T1-weighted contrast-enhanced images for the first and second datasets, respectively. The proposed network structure achieves a big performance with the simplest overall accuracy of 96.13% and 98.7%, respectively, for the two studies. The results indicate the power of the model for brain tumor multi-classification purposes.

Brain tumor can be defined as unnatural and uncontrolled growth in brain cells. Since the human skull is a rigid and volume limited body, consequently any unexpected growth may affect a human function according to the involved part of the brain. Moreover, it may spread into other body organs and affect human functions [1]. According to the world cancer report published by the World Health Organization (WHO), brain cancer accounts for less than 2% of human cancer; however, severe morbidity and complications are produced [2]. Cancer research corporation in the United Kingdom mentioned that there are about 5,250 deaths annually by the act of brain, other Central Nervous System (CNS) and intracranial tumors in the UK. Brain tumors can be classified in many ways, for instance, primary and secondary tumors. The former represents about 70% of all brain tumors, while secondary tumors are the residuals 30%.

B. Magnetic resonance imaging– based brain tumor grades classification and grading via convolution neural networks and genetic algorithms.

Gliomas are the foremost common type of primary brain tumors in adults and their early detection is of great importance. In this work, an approach based on convolutional neural networks (CNNs) and genetic algorithm (ga (GA) is described for using magnetic resonance imaging to noninvasively characterize various sorts of glioma (MRI).During this method, the architecture of the CNN is evolved using Genetic Algorithm, unlike existing methods of choosing a deep neural network architecture which are supported on trial and error or by adopting predefined structures. To decrease the variance of prediction error, bagging as an ensemble algorithm is used on the best model developed by the GA. To briefly mention the results, in a case study, 90.9 percent accuracy of classifying three Glioma grades was obtained. In other case study, Glioma and Meningioma, and Pituitary tumor types were classified with 94.2 percent accuracy. The results reveal the effectiveness of the proposed method in classifying brain tumor by MRI images. Due to the flexibility of the method, it can be readily used in practice for assisting the doctor to diagnose brain tumors in early stages [2-4].

Monitoring of important signs using the photoplethysmography (PPG) signal is applicable for the development of home-based healthcare systems within the aspect of practicability, mobility, comfort, and cost-effectiveness of the PPG device. In this paper, a new technique based on the variational mode decomposition (VMD) for roughly calculating heart rate (HR) from the PPG signal is proposed. A PPG signal is filtered into a variety of formats or sub-signals by the VMD. Thereafter, the modes that are influenced by HR data are identified and progressively replaced in order to extract the patient's HR. The proposed scheme is checked over an outsized number of recordings obtained from three independent databases, namely the Capnobase, MIMIC, and University of Queens Vital Sign (UQVS). Experiments are performed over the different data length segments of the PPG recordings.

C. Localization and classification of brain tumor using machine learning & deep learning technique

Digital image processing is a rising field for the investigation of complicated diseases such as brain tumor, breast cancer, kidney stones, lung cancer, ovarian cancer, and cervix cancer and so on. The recognition of the brain tumor is considered to be a very critical task. A number of approaches are used for the scanning of a particular body part like CT scan, X-rays, and Magnetic Resonance Image (MRI). These pictures are then examined by the surgeons for the removal of the problem. The main objective of examining these MRI images (mainly) is to extract the meaningful information with high accuracy. Machine Learning and Deep Learning algorithms are mainly used for analyzing the medical images which can identify, localize and classify the brain tumor into sub categories, according to which the diagnosis would be done by the professionals. In this paper, we have discussed the different techniques that are used for tumor pre-processing, segmentation, localization, extraction of features and classification and summarize more than 30 contributions to this field. Also, we discussed the existing state-of- the-art, literature gaps, open challenges and future scope in this area.

Brain Tumor Detection is one of the critical tasks in the analysis of medical images. When the cells presented within the human brain increases unusually or abnormally, then this condition is known as brain tumor. In general cases its growth starts from the nerves coming out of the brain, brain cells and the vessels of blood. Tumors can be categorized in two forms and they are malignant (cancerous) and benign (non-cancerous) tumors. Benign tumors are considered as slow increasing tumors. The benign tumors do not extend in the adjoining brain tissue. These tumors will only apply potentially harmful pressure. The malignant tumors are described as fast increasing tumors. These tumors are capable to extend in the surrounding brain. The normal brain cells can be destructed by the tumors because of the generation of inflammation, applying pressure on the brain parts and rising pressure into the head [3].

D. Automatic segmentation and classification of brain tumor using machine learning techniques

In the field of Medicine, especially within the applications that are used for diagnosis purpose, detecting a fault may be a major task and needs lots of attention of the radiologist. Early defect detection is important to avoid further complications. The most actively developing field within the recent technology is that the MRI scanning. The size of the tumor in brain can vary differently for various patients alongside the minute details of the tumor, it he radiologists' role of evaluating and grading the malignancy from a vast number of images is complex and time-consuming. Sometimes, cerebral fluid also seems to be seen as a mass of tissue within the MRI image. The project aims to have an automated system which plays a important role in assessing whether a lump (mass of tissue) in the brain could be benign (clump thickness) or malignant (marginal adhesion) by classification.

The proposed model uses machine learning algorithms so as to enhance the accuracy of classification. The system is run call at four steps that has pre-processing for noise removal using adaptive median filter, segmentation using Gaussian Mixture Model (GMM) for locating the region of interest, feature extraction using Grey Level Co-occurrence Matrix GLCM for extracting the features of various sort of tumors and classification using Neural Networks (NN) to determine and classify the tumor as benign or malignant. The experimental results of the proposed model show that 93.33% accuracy, 96.6% specificity, 93.33% sensitivity and precision with 94.44%. From these results the proposed model works better when compared with the classical machine learning algorithms like Adaboost (Adaptive Boosting) which classifies the image into different classes (Normal, Benign, Malignant) with 89.90% accuracy [5].

Brain tumor is known to cause major backdrop for the rapid increase in the mortality among the children, adult and especially in the old aged people. Because the human body is made up of millions of cells, we know that cells replicate, grow, and divide in order to develop new cells and tissues. External influences may cause the cells to develop uncontrolled, leading to the creation of a malignancy. Tumors are divided into two types: benign malignancies and cancer progression. Benign cysts are less destructive since they do not spread to other cells. Whereas malignant tumors are those mass of cells which are cancerous, harmful and are more likely to spread across.

E. Capsule network for brain tumor classification based on MRI images and course tumor boundaries

According to official statistics, cancer is taken into account because the second leading cause of human fatalities. Among differing kinds of cancer, brain tumor is seen together of the deadliest forms due to its aggressive nature, heterogeneous characteristics, and low relative survival rate. Determining the sort of brain tumor has significant impact on the treatment choice and patient's survival. Human-centered diagnosis is typically error-prone and unreliable leading to a recent surge of interest to automatize this process using convolutional neural networks (CNNs). CNNs, however, fail to completely utilize spatial relations, which is harmful for tumor classification, because the relation between the tumor and its surrounding tissue may be a critical indicator of the tumor's type. In our recent work, we have incorporated newly developed CapsNets to beat this shortcoming. CapsNets are, however, sensitive to the miscellaneous image background. The paper addresses this gap. The main contribution is to equip CapsNet with access to the tumor surrounding tissues, without distracting it from the most target. A modified CapsNet architecture is, therefore proposed for brain tumor classification, which takes the tumor coarse boundaries as extra inputs within its pipeline to extend the Caps Net’s focus. The presented scheme outperforms its contemporaries greatly [7-9].

According to statistics from the World Health Organization, cancer is the second major cause of human death globally, accounting for nearly 9.6 million deaths this year. Among different sort of cancers, brain tumor is widely seen [1] together of the deadliest because of its aggressive nature, heterogeneous characteristics (types), and low relative survival rate, cancer is one of the most terrible diseases (e.g. , in US relative survival rate following a diagnosis of a primary malignant brain tumour is around 35 percent). For both patients and their families, this cancer can also have a significant impact on the outcomes of life. The key think about treating brain cancer and increasing its survivability rate is early diagnosis and properly determining its type. Brain tumor can have different types depending on several factors such as the shape, texture, and location of the tumor. Determining the correct type of brain tumor is of paramount importance, as it can significantly influence the choice of treatment and predicting patient’s survival.

F. Brain tumor segmentation using convolutional neural networks in MRI images

Among brain tumors, gliomas are the foremost common and aggressive, resulting in a really short anticipation in their highest grade. Thus, treatment planning may be a key stage to enhance the standard of lifetime of oncological patients. Magnetic resonance imaging (MRI) may be a widely used imaging technique to assess these tumors, but the massive amount of knowledge produced by MRI prevents manual segmentation during a reasonable time, limiting the use of precise quantitative measurements in the clinical practice. So, automatic and reliable segmentation methods are required; however, the huge spatial and structural variability among brain tumors make automatic segmentation a challenging problem. In this paper, we propose an automatic segmentation method supported Convolutional Neural Networks (CNN), exploring small 3 ×3 kernels. The utilization of little pieces permits planning a more profound design, other than having a constructive outcome against overfitting, given the more modest number of loads inside the organization. We additionally researched the utilization of force standardization as a pre-preparing step, which however not regular in CNN-based division strategies, demonstrated related to information increase to be exceptionally successful for cerebrum tumor division in MRI pictures. Our proposition was approved inside the mind tumor Segmentation Challenge 2013 data set (BRATS 2013), acquiring at the same time the primary situation for the entire, center, and upgrading locales in Dice Similarity Coefficient metric (0.88, 0.83, 0. 77) for the Challenge informational index. Also, it obtained the general first position by the web evaluation platform. We also participated within the on-site BRATS 2015 Challenge using the same model, getting the subsequent spot, with Dice Similarity Coefficient metric of 0.78, 0.65, and 0. 75 for the total, center, and improving areas, separately [9].

G. Brain tumor segmentation with deep learning technique

The proposed work depends on Deep learning method which is a profound neural organization and probabilistic neural organization to recognize undesirable masses in the mind. Our work is customized for both high and low-level evaluations. Tumors can show up in wherever of the mind and its temperaments like shape, difference, and size have consistently been an unsure one, which implies that there is no standard reality about tumor structure. The rate at which individuals burden from cerebrum tumor becomes expanding these days. These reasons animate us to give a canny arrangement which utilizes profound learning strategy to section unusual tissues in the mind. It can assist with seeing if the tumor is in the cerebrum or not. With the assistance of these MRI pictures, division can be performed and the fragmented pictures can measure up to the typical cerebrum tissues additionally with the tumor cells. The results are provided (whether the brain contains a tumor or not) based on the comparison. In this paper, the segmentation is done using a convolution neural network and Probabilistic neural network. Here, the comparison sketch of various models is done. Based on that, we discovered an architecture which is based on Convolutional Neural Networks (CNN) with both 3*3 and 7*7 in an overlapped manner, and build a cascaded architecture, so that we can able to segment a tumor accurately in an effective manner, since we use Image dataset Brats13. Similarly, we use a probabilistic neural network for detecting tumors and compare the result of both of them. We proposed a unique CNN and PNN architectures which are different from those conventional models used in image processing and computer vision techniques. Our model deals with both local and global features.

H. Survey on brain tumor segmentation methods

The segmentation of brain tumor using resonance Image (MRI) plays a crucial role within the medical image process. This paper presents a comprehensive survey on brain tumor methods and technology using MRI images. Generally, brain tumor segmentation methods can divide into two main categories, spatial continuous and spatial discrete methods. Several methods, techniques, related advantage and weakness are going to be described and discussed. The evaluation measures are mentioned and therefore the qualities of various method specialize in the methods that were applied on the quality data sets. The efficient and stably brain tumor segmentation is still a challenging task for the unpredictable appearance and shape of the brain tumor.

Brain tumor segmentation and localization play important roles in image-guided therapy. Radiation oncologists extensively use the magnetic resonance image to diagnose brain tumors. Brain tumor segmentation and detection will provide information associated to anatomical structures also as potential abnormal tissues necessary to treatment planning and patient follow-up. Accurate segmentation of brain tumors in MRI can also help for modeling of pathological brains and locate the spatial position of the brain anatomical structures. The goal of brain tumors segmentation is to label the pixels (voxels) into appropriate classes, which may be normal tissues or abnormal pathological tissues. In current practice, the radiation oncologist has to perform these tasks manually. During the processing of mass 3D MRI, medical experts accurately label brain tumors and associated edema in magnetic resonance images with slice by slice is a tedious and particularly time-consuming task. There exists significant variation between the segmentation labels produced by different medical experts. Further, the segmentations produced by the same expert in different settings are also subject to variations. Furthermore, limiting the global perspective and potentially is limited by labeling the tumor slice-by-slice, and will generate sub-optimal segmentations. The process of segmenting tumors in MRI images is particularly challenging compared with natural scenes for several reasons. The tumors vary greatly in size and position and have various shapes and appearance properties. In addition, tumors have intensities overlapping with normal brain tissue. Often, an expanding tumor detects and deforms nearby structures in the brain, thereby giving an abnormal geometry for the healthy tissues as well.

I. Detection of brain tumor from MRI images by using segmentation & SVM

It is an important to find out tumor from MRI images but it is somewhat time-consuming and difficult task sometime performed manually by medical experts. Large amount of time was spent by radiologist and doctors for identification of tumor and segmenting it from other brain tissues. Nonetheless, careful naming mind tumors is a tedious undertaking, and significant variety is seen between specialists. Consequently, throughout the most recent decade, from different examination results it is being seen that it is extremely tedious strategy yet it will get quicker on the off chance that we use picture handling procedures. Essential mind tumors don't spread to other body parts and can be dangerous or benevolent and auxiliary cerebrum tumors are consistently threatening. Harmful tumor is more perilous and hazardous than kind tumor. The considerate tumor is simpler to distinguish than the dangerous tumor. Likewise, the primary stage tumor might be harmful of kindhearted however after first stage it will change to risky dangerous tumor which is hazardous. Diverse mind tumor recognition calculations have been created in the previous few years. Regularly, the programmed division issue is exceptionally difficult and it is yet to be completely and agreeably addressed. The principle point of this framework is to make a mechanized framework for recognizing and distinguishing the tumor from typical MRI. It considers the factual highlights of the mind construction to address it by critical component focuses. Most of the early methods obtainable for tumor detection and segmentation may be largely divided into three groupings: region-based, edge-based and fusion of region and edge-based methods. Well known and broadly used segmentation techniques are K-Means clustering algorithm, unsupervised method based on neural network classifier. Also, the time spent to segment the tumor is getting condensed due to the detailed demonstration of the medical image by withdrawal of feature points. Region- based techniques look for the regions satisfying a given homogeneity standards and edge-based segmentation methods look for edges between regions with different characteristics [4-9].

Title	Keywords	Advantage	Disadvantage
Localization and Classification of Brain Tumor using Machine	Brain Tumor, MRI, Machine Learning	SVM produces good results in normal execution time	CNN is very expensive and requires lot of dataset for achieving the best results

Learning & Deep Learning Technique			
Automatic Segmentation and classification of Brain Tumor using Machine Learning techniques	Adaptive Median Filter, K-means, GMM Segmentation, GLCM, Neural Networks	Works better when compared with the classical machine learning algorithms	Require more execution time and it only consider small dataset
Capsule network for brain tumor classification based on MRI images and course tumor boundaries	Brain Tumor Classification, Capsule Networks, Tumor Boundary, Convolutional Neural Networks.	Need for tumor exact annotation is eliminated, and; it helps the CapsNet to focus on main area, and consider its relation with surrounding tissues.	Interpretability of CapsNets for the brain tumor classification is not explained
Brain Tumor Segmentation Using Convolutional Neural Networks in MRI Images	Tumors, Image segmentation, Magnetic resonance imaging, Kernel, Training, Brain modeling	Able to reduce the computation time approximately by ten-fold	Is more costly than other
Brain tumor segmentation with deep learning technique	CNN, PNN, Kernels, Deep learning and Computer vision, Segmentation	This model deals with both local and global features	Is time consuming
Survey on Brain Tumor Segmentation Methods Multi – classification of Brain Tumor Images Using Deep Neural Network	Brain tumor segmentation, survey, Magnetic Tumors, Feature extraction, Cancer, Task analysis, Convolutional neural networks, Training	Accurate segmentation of brain tumors in MRI Highest accuracy of 96.13% and 98.7% concerning the two datasets	Existing methods leave Dataset is small
Magnetic resonance imaging– based brain tumor grades classification and grading via convolution neural networks and genetic algorithms	Image classification CNN, Genetic algorithms, Bagging ensemble algorithm, Resonance Image, segmentation	Time required for classification is short as compared to biopsy	Impossible to evaluate all possible cases significant room for increased automation, applicability and accuracy of the brain tumor segmentation
Detection of Brain Tumor from MR Image using segmentation and SVM	K-Means algorithm, Object Labelling Algorithm, Image segmentation	To find out tutor size and also, can evaluate its tumour type and also its stage by using the intensities of MRI. Uses the intensity of MRI images to place different colour on the image	Cannot find out its tumour size and also evaluate its tumour types and also its stage of tumour

Table 1: Comparison table based on the existing method.

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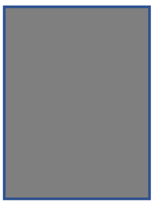
Author Biographies



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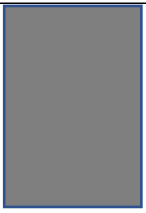

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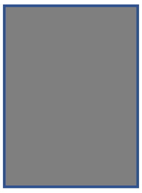

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